THE EFFECTS OF FOCUS OF ATTENTION ON THE LEARNING OF THE CLEAN WEIGHTLIFTING TECHNIQUE IN NOVICES

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The purpose of this study was to assess the effects of different focus of attention (FOA) feedback on the learning of the clean weightlifting technique. Sixteen participants naive to the task were divided into two groups (external and internal FOA) and attended three sessions of learning. Bar and lifter kinematics were measured prior to and after learning, and retention and transfer tests were performed seven days after protocol completion. Internal FOA feedback promoted greater reduction of the distance between the bar and the lifter's body, whereas both types of feedback were found to be equally effective at modifying hip, knee and ankle flexion/extension patterns in the pulling phases of the lift. There seems to be insufficient evidence to advise coaches to choose one type of FOA feedback exclusively, as each approach could target different needs/stages of learning.

KEY WORDS: motor learning, skill acquisition, coaching, bar kinematics, lifter kinematics.

INTRODUCTION: Focus of attention (FOA) refers to the information an athlete processes when performing a motor task. Two forms of FOA exist: *external (EFOA),* when information relates to movement outcome; or *internal (IFOA)*, when the attention is on aspects of movement execution (i.e. technique). According to the Constrained-Action Hypothesis (Wulf, 2013) EFOA promotes better automaticity in task execution and is more beneficial than IFOA in the performance and learning of motor skills. However, the benefits of EFOA may be modulated by skill level and appear inconsistent in inexperienced populations (Poolton, Maxwell, Masters, & Raab, 2006). Furthermore, the assumption of naivety to the skill could be arguable when the motor task is too simple (Peh, Chow, & Davids, 2011). Previous motor learning research has usually observed movements lacking complex coordination structures and/or complex object manipulations, and has typically analysed outcome performance (i.e. what was achieved?) as opposed to movement execution (i.e. how was it achieved?).
The *clean* is a weightlifting movement in which a powerful extension of the hips and knees, and ankle plantar flexion (i.e. triple extension) are used to lift a barbell from the floor up to the shoulders (Kipp, Redden, Sabbick & Harris, 2012). With an increase of weight on the bar, the athlete's technique becomes crucial to lifting in an efficient way and in reducing excessive joint load. Despite the multiple lifting styles amongst competitive athletes, minimal horizontal bar displacement (Ammar et al., 2017; Kipp & Meinerz, 2017) and reduced distance between the bar and lifter's body (Schutts, Wu, Vidal, Hiegel, & Becker, 2017) have been highlighted as key factors for a mechanically efficient technique. The increased popularity of the clean as a strength & conditioning tool even for beginners, emphasizes the need for more scientific evidence to inform best coaching practices (Storey & Smith, 2012).
Therefore, the purpose of this study was to compare the effects of EFOA and IFOA on the learning of the clean weightlifting technique. Outcomes of this study will help coaches choose the most effective feedback information for beginners aiming to learn this movement.
METHODS: Sixteen participants (10 male, 6 female; age: 26.9 ± 4.6; height: 1.74 ± 0.09 m; mass: 70.7 ± 13.2 kg) were randomly assigned to one of two groups (EFOA or IFOA) with a matched number of males and females. All participants reported to be naive to the clean exercise and gave informed consent before partaking in the study, which received ethical approval (REACH, University of Bath). A 15 kg bar with two discs (1.14 kg; radius = 0.25 m) were used during the learning protocol, with individual grip width maintained across sessions. Video footage of a professional weightlifter's clean was shown to participants once prior to testing, without any further instruction provided. Participants were asked to perform six sets of three repetitions of the clean on three separate sessions (Day 1-3, separated by at least one day). Each session was preceded by a standardised warm-up (10 squats, 10 lateral and

20 forward lunges alternating legs) and two minutes of rest was given between sets. After each set, a qualified coach provided verbal feedback choosing from a pool of pre-defined EFOA or IFOA instructions, depending on the group. Movement technique and outcome were measured, pre- (Day 1) and post- (Day 3) intervention, and in retention and transfer tests (i.e. 5 kg added to the bar), which were undertaken seven days later.

Motion capture (Oqus, Qualisys, Sweden) was used to measure whole body and bar kinematics. Marker trajectories were low-pass filtered (4^{th} order zero lag Butterworth, 6 Hz cut-off) and inverse kinematics was used to estimate lower limb joint angles (Visual 3D^{TM}, C-Motion, USA). The following movement phases and pre-set positions were identified for technique analysis (Ammar et al., 2017):

- *First pull*: from the frame prior to the bar lift off (*start*) to bar at knee height (i.e. when the bar crosses the knee joint centre in the vertical direction).
- *Transition phase*: from bar at knee height to *power position* (i.e. when the bar crosses the middle point between the hip and knee joint centres in the vertical direction).
- *Second pull*: from power to *drop* position (max knee extension after power position).
- *Drop*: from drop to *catch* position (minimum bar height after the second pull) including *bar's most forward* position (peak anterior position of the bar).
- *Recovery*: from catch position to bar resting on the shoulders.

Custom Matlab scripts (Mathworks Inc, Massachusetts, USA) were developed to identify individual lifting phases, calculate the horizontal displacement of the bar and the horizontal distance from the bar centre to the lifter's centre of mass (COM) within each phase. Right lower limb kinematics in the sagittal plane was considered in this study. All variables were time registered to 1001 points.

Repeated measures ANOVA (2 Groups x 4 Sessions) with Bonferroni post-hoc tests and effect sizes (Cohen's *d*) were performed to assess the effect of EFOA and IFOA on 0D variables: peak horizontal bar displacement during the first pull (including the transition phase), second pull and drop phase; distance between the bar and lifter's COM at start, power, drop, bar's most forward, and catch position. Statistical parametric mapping (SPM, www.spm1d.org) was used to perform the same statistical analysis on 1D variables: distance from the bar to lifter's COM; hip, knee and ankle flexion/extension angles. The level of significance for 0D and 1D analyses was set at $\alpha = 0.05$.

RESULTS: *0D analysis* – EFOA and IFOA groups did not show any differences in horizontal bar displacement over the learning protocol in any movement phase. The IFOA group exhibited smaller horizontal bar displacement during the first pull and transition phase (main effect of Group, $p = 0.010$, $d = 1$). The type of feedback did not affect the change in the distance between the bar and lifter's COM over time. Both groups significantly reduced this distance with learning (main effect of Session) at the start ($p = 0.040$), power ($p < 0.001$) and bar's most forward positions ($p < 0.001$). Bonferroni's post hoc tests revealed that this reduction was produced between the pre- and post-test (power position, $p = 0.001$, $d = 1.64$; bar's most forward position, $p = 0.004$, $d = 1.34$). This change was still present after a week, as no significant differences were found between post-test and retention and transfer tests.

1D analysis – IFOA feedback promoted a greater reduction of the bar to lifter's COM distance at the beginning of the drop phase (interaction effect, $p = 0.010$, 36-47% of the lift). This distance was also reduced in both groups within the first pull, transition phase and second pull as an effect of learning ($p < 0.001$, 0-26% of the lift). These results are presented in Figure 1. IFOA and EFOA did not differ in their effect on hip, knee and ankle flexion/extension pattern changes over time. Learning (Session effect) promoted greater extension of the hip ($p = 0.009$, 2-14% and $p < 0.001$, 18-36% of the lift) and knee ($p < 0.001$, 4-31% of the lift) in the first pull, transition phase and second pull, regardless of feedback type. Similarly, both groups showed greater plantar flexion in the second pull ($p = 0.001$, 21-33% of the lift) and greater dorsiflexion when transitioning from the drop to recovery phase ($p < 0.001$, 52-78% of the lift) after the learning protocol (Figure 2).

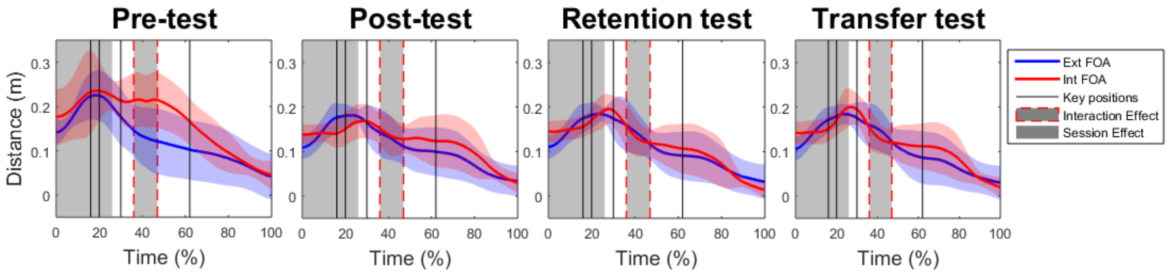

Figure 1: Horizontal distance from the bar to lifter's COM (group mean and standard deviation). Key positions, i.e. bar at knee height (16%), power (20%), drop (30%) and catch (62%), are population averages. Group x Session interaction effect (36-46%) and Session effect (0-26%) are the results of SPM ANOVA.

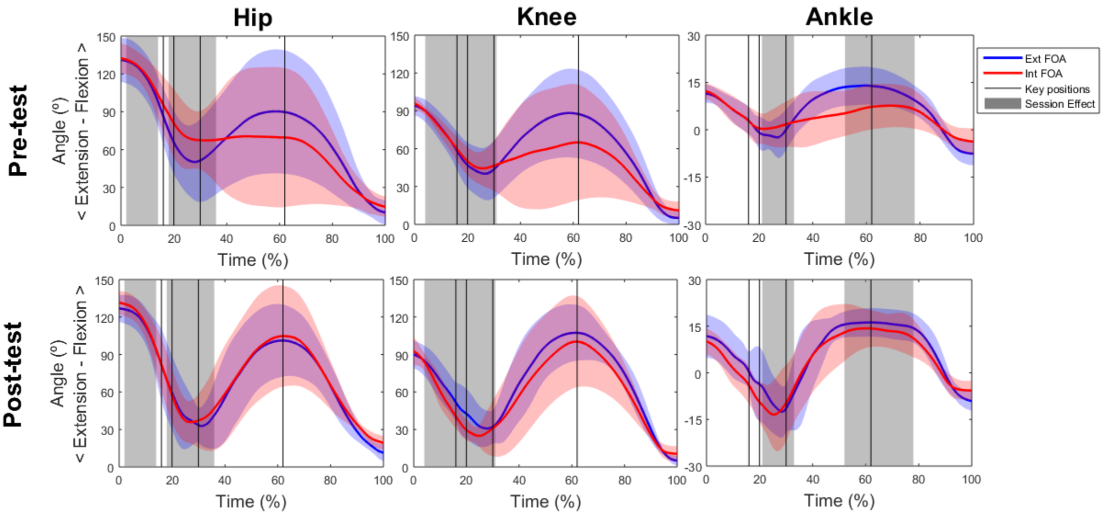

Figure 2: Sagittal plane joint angles (group mean and standard deviation). Key positions, i.e. bar at knee height (16%), power (20%), drop (30%) and catch (62%), are population averages. For sake of clarity and due to similarities between post-, retention and transfer tests, only pre- and post-test data are reported. Session effects are the results of SPM ANOVA.

DISCUSSION: The purpose of this study was to compare the effects of EFOA and IFOA feedback on the learning of the clean weightlifting technique in a population naive to the task. After the learning protocol, participants' technique improved within both groups. IFOA group showed greater reduction in the distance between the bar and the lifter's COM in the drop phase. Both EFOA and IFOA feedback induced greater hip and knee extension and ankle plantar flexion in the first pull, transition phase and second pull, and greater dorsiflexion around the catch position, without evident distinction between groups. The learning was equally maintained across both groups a week after completion of the learning protocol (i.e. retention test), and when the mass lifted was increased (i.e. transfer test).

Our results suggest that EFOA and IFOA were equally effective in modifying hip, knee and ankle flexion/extension angular profiles throughout the lift. IFOA seemed more effective in reducing the distance between the bar and the lifter's COM when transitioning from the drop to the recovery phase. However, the behaviour of the two groups at baseline (i.e. pre-test) showed different patterns despite random assignment of participants. Participants' previous experiences or generic motor skills may have conditioned their approach to the studied movement and this warrants careful analysis/selection of the samples and grouping when inexperienced participants are studied.

In contrast with recent work that found EFOA to be more beneficial in experienced lifters (Schutts et al., 2017), our study suggests that IFOA may be more effective for beginners in reducing the distance between the bar and the lifter's body at certain phases. This seems to reinforce that skill level is a mediator of the effect of FOA (Poolton et al., 2006). When expertise is developed, movement execution is thought to be achieved through patterns that can function automatically without the assistance of attention (Gray, 2004). Conversely, novices are challenged to acquire a functional movement pattern that responds to the demands of the new motor task. This is accomplished by assembling a set of already existing – but unintegrated at this stage – motor patterns (Gray, 2004). Although researchers have not come to a definite conclusion about the effect of FOA, IFOA could be beneficial in the acquisition of movement fundamentals. IFOA has also been advised in later stages of learning when the purpose of the task is to modify/correct a specific part of the movement (Lohse, Sherwood, & Healy, 2014). Once the new modification is incorporated by the athlete, the movement could be performed automatically and attention can therefore be directed to movement outcome (i.e. EFOA).

The duration of the learning protocol was a limitation of this study as the clean is a highly complex movement that takes years to master. This may explain, for instance, why knee flexion (double knee bend) was not observed during the transition phase. The use of a standardised mass for every participant (17.28 kg) potentially represented another limiting factor. However, this choice was made after thorough discussion with an experienced S&C coach who acknowledged this as a common practice when introducing beginners to the clean. Future studies should aim to compare the effects of FOA within a longer training program and exploring the use of subject-specific selection of lift mass. Also, further research is needed to understand the effects of FOA on trunk and upper-limb technique and multi-segment coordination, which may also have implications for injury prevention.

CONCLUSION: EFOA and IFOA feedback seem equally effective at modifying lower limb kinematics in naive athletes learning the clean weightlifting technique. IFOA promoted greater reduction in the distance between the bar and lifter's COM, but there is insufficient evidence to indicate one type of feedback over the other in the early stages of learning. Coaches are advised to consider the objectives of the task and combine the feedback type according to the specific needs of their athletes when teaching the clean technique.

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